US-PAT-NO: 6310576

DOCUMENT-IDENTIFIER: US 6310576 B1

TITLE: Method of identifying location using a master clock to synchronize time of arrival signals

---------- KWIC ---------

Abstract Text - ABTX (1):

A method is provided of identifying position location of a transmitter device, such as a mobile or portable, in an inbound system. The inbound system includes free receivers all coupled, over appropriate radio frequency (RF) links, to a common reference receiver, the latter equipped with a high precision timebase master clock for receiver synchronization purposes. Rather than requiring each and every receiver to maintain a separate high-precision timebase to record position related timing signals for position location determination, in accordance with a preferred embodiment, the free receivers are configured to detect timing signals from the transmitter device, and without timestamping them, quickly forward them (in the form of a signal-received indication) after a fixed or otherwise known time delay to the reference receiver. The reference receiver, in turn, timestamps all signals from all free receivers according to its own master clock high precision timebase. In this way, it is possible to synchronize the forwarded signal-received indications to the reference receiver master clock and to use the results to derive useful position location information. This is achieved without equipping high precision timebase clocks in the free receivers, which in most instances is prohibitively expensive.

Detailed Description Text - DETX (2):

Generally, the present invention involves an improved and less costly method of identifying position location of a transmitter device, such as a mobile or portable, in an inbound system. The inbound system includes free receivers all coupled, over appropriate radio frequency (RF) links, to a common reference

receiver, the latter equipped with a high precision timebase master clock for receiver synchronization purposes. Rather than requiring each and every receiver to maintain a separate high-precision timebase to record position related timing signals for position location determination, in accordance with a preferred embodiment, the free receivers are configured to detect timing signals from the transmitter device, and without timestamping them, quickly forward them (in the form of a signal-received indication) after a fixed or otherwise known time delay to the reference receiver. The reference receiver, in turn, timestamps all signals from all free receivers according to its own master clock high precision timebase. In this way, it is possible to synchronize the forwarded signal-received indications to the reference receiver master clock and to use the results to derive useful position location information. This is achieved without equipping high precision timebase clocks in the free receivers, which in most instances is prohibitively expensive.

Detailed Description Text - DETX (5):

In inbound system 200 there are included a plurality of free receivers 221-223 and a common reference receiver 224 coupled to receive a timing signal broadcast from a transmitter device 230, which signal travels over direct RF paths 241-244 to each of the receivers 221-224, respectively. As explained in connection with prior art system 100 depicted in FIG. 1, the transmitter may be any mobile or portable device capable of transmitting a signal detectable by receivers 221-224. Each free receiver 221-223 is coupled by way of an associated RF link 251-253 to common reference receiver 224. Reference receiver 224 scans the RF links 251-253 for associated signal-received indications from each of free receivers 221-223. Each signal-received indication is timestamped using the common receiver's independently-running clock 260. Clock 260 may be an atomic (cesium timebase) clock, an oven-controlled oscillator type clock, or the like high-precision timebase source. In the illustrative embodiment, free receivers 221-223, which may be base station receivers or repeaters, are not provided with high-precision clocks, as was the case for receivers 121-123 in prior art system 100.

Detailed Description Text - DETX (6):

Inbound system 200 obviates the need for independently-running clocks in each of free receivers 221-223, thus eliminating the need to also synchronize such clocks. As will be explained in greater detail below, each receiver 221-223 reports arrival information, in the form of a signal-received indication, directly over RF links 241-243, to common receiver 224, which does have a clock and does timestamp the separately received signal-received indication from each free receiver.

Detailed Description Text - DETX (10):

Referring to FIG. 3, reference receiver 300 includes position locating means 310 for performing position location calculations and is configured to receive signal-received indications, over RF links 241-243--but, unlike system 200, not from transmitter 230 directly. Reference receiver 300 may be attractive as a bare bones add-on component in existing communication systems where none of the receivers may be provided with high precision timebases, so as to readily and at low cost provide high-accuracy position location functionality thereto. In the implementation contemplated by FIG. 3, it is not intended that reference receiver 300 be configured to process voice/data communications, but only sufficient timing signal processing capability (i.e., capability to process signal-received indication signals) to interface with free receivers 221-223 tirelessly coupled thereto.

Detailed Description Text - DETX (12):

At time t(-1), transmitter 230 broadcasts a timing signal (405). At times t(0), t(1), t(3) and t(2), each of free receivers 221-223 and reference receiver 224 receive the timing signal (410-440). In this exemplary embodiment, the timing signal arrives at reference 224 a short while t(2) before it arrives at free receiver 223 t(3). Reference receiver 224 immediately generates a timestamp signal, using internal clock 260, to record arrival time t(3) (435). Free receiver 221 generates a non-timestamped signal-received indication type timing signal and transmits it after an optional known delay period d.sub.a (450). Similarly, free receivers 222 and 223 generate non-timestamped signal-received indications and transmit them after associated optional known delay periods d.sub.b and d.sub.c (460, 470).

Detailed Description Text - DETX (13):
Non-timestamped, signal-received signals from each of free receivers 221-223
are received by reference receiver 224 at times t(4), t(6) and t(5) respectively, which times include associated known delay periods d.sub.a,
d.sub.b and d.sub.c as well as known propagation delay times d.sub.f, d.sub.g
and d.sub.h corresponding to the travel time of those signals to reference
receiver 224 (480-500). Reference receiver 224 then generates a timestamp
t(4), t(6), and t(5) for each of the signal-received indications from free
receivers 221-223 (510-530), and forwards the timestamp data signals to navigation console 281 (540). Console 281 subtracts the known optional delay
periods d.sub.a, d.sub.b and d.sub.c and the known propagation delay periods
d.sub.f, d.sub.g and d.sub.h from the timestamped values to arrive at the
actual timing signal arrival times t(0), t(1), t(3) at each of free receiver
221-223, respectively (550).

Detailed Description Text - DETX (15):
It should be understood that once the timing signal is detected, reference
receiver 224 does not need to send out a signal-received indication. Instead,
it merely generates a timestamped signal which is then reported together with
the timestamped signals (reports) from each of free receivers 221-223, to
navigation console 281.

Claims Text - CLTX (3):
receiving the timing signal at the first free receiver at time t(0) and
transmitting a first non-timestamped, signal-received indication over a communication link with predictable delay to the common reference receiver
after a first known delay-reporting period has elapsed;

Claims Text - CLTX (4):
receiving the timing signal at the second free receiver at time t(1) and
transmitting a second non-timestamped, signal-received indication over a
communication link with predictable delay to the common reference receiver
after a second known delay-reporting period has lapsed; and

Claims Text - CLTX (5):
receiving, by the common reference receiver, the first and second non-timestamped, signal-received indications and, in response thereto, generating corresponding first and second timestamped signals using the master
clock as a common synchronizing timebase.

Claims Text - CLTX (12):
6. The method of claim 3, wherein the first and second non-timestamped,
signal-received indications transmitted by each of said first and second free
receivers, respectively, to said common reference receiver, are timing type
signals.

Claims Text - CLTX (13):
7. The method of claim 3, wherein said common reference receiver is a
multi-channel type receiver for receiving each of said first and second non-timestamped, signal-received indications on any one of a frequency, code,
or time division multiplex manner.

Claims Text - CLTX (22):
13. The method of claim 10, wherein the first and second non-timestamped,
signal-received indications transmitted by each of said first and second free
receivers, respectively, to said common reference receiver, are timing type
signals.

Claims Text - CLTX (23):
14. The method of claim 10, wherein said common reference receiver is a
multi-channel type receiver for receiving each of said first and second non-timestamped, signal-received indications on any one of a frequency, code,
or time division multiplex manner.

Claims Text - CLTX (25):
16. The method of claim 1, wherein the first and second non-timestamped,
signal-received indications transmitted by each of said first and second free
receivers, respectively, to said common reference receiver, are timing type
signals.

Claims Text - CLTX (26):
17. The method of claim 1, wherein said common reference receiver

is a
multi-channel type receiver for receiving each of said first and second non-timestamped, signal-received indications on any one of a frequency, code,
or time division multiplex manner.

Claims Text - CLTX (31):
receiving the timing signal at the first receiver at time t(0) and transmitting a first non-timestainped, signal-received indication over a
communication link to the common reference receiver after a first known delay-reporting period has lapsed;

Claims Text - CLTX (33):
receiving, by the common reference receiver, the first and second non-timestamped, signal-received indications and, in response thereto, generating corresponding first and second timestamped signals using the master
clock as a common synchronizing timebase.